

11-76-111
001T
112401
7P

SEMIANNUAL PROGRESS REPORT

Grant NAG8-239

MAGNETOSPHERIC SPACE PLASMA INVESTIGATIONS

August 1994 -January 1995

by

Richard H. Comfort

and

James L. Horwitz

Prepared for

National Aeronautics and Space Administration
George C. Marshall Space Flight center
Marshall Space Flight Center, Alabama 35812

Submitted by

The University of Alabama in Huntsville
Center for Space Plasma and Aeronomic Research
and
College of Science
Huntsville, Alabama 35899

February, 1995

N95-22955

Unclass

G3/75 0042407

(NASA-CR-197405) MAGNETOSPHERIC
SPACE PLASMA INVESTIGATIONS
Semiannual Progress Report, 1 Aug.
1994 - 31 Jan. 1995 (Alabama
Univ.) 7 p

MAGNETOSPHERIC SPACE PLASMA INVESTIGATIONS

SCIENTIFIC INVESTIGATIONS

Generalized SemiKinetic (GSK)

A single, relatively benign, referee's report was received for the JGR paper on GSK modeling of the synergistic interaction of transverse heating of ionospheric ions and magnetospheric plasma-driven electric potentials on the auroral plasma transport [Ref. 1]. The paper was revised accordingly and re-submitted, and we expect it will be accepted.

The presentations on modeling of effects of auroral electron precipitation on ionospheric plasma outflow [Ref. 2], on ExB effects on such outflow [Ref. 3], and on warm plasma thermalization and other effects during refilling with pre-existing warm plasmas [Ref. 4] were presented at the October workshop in Guntersville on "Coupling of Micro and Mesoscale Processes in Space Plasma Transport". These are in final preparation for submission as contributions for the AGU monograph on "Cross-scale Coupling in Space Plasmas" [Ref. 29-31].

We have initiated some other new topics during this period. One of these concerns substorm dipolarization effects on middle magnetosphere plasma distributions. We find effects of equatorial heating and trapping of ions primarily by betatron acceleration, and development of field-aligned ion distributions at off-equatorial latitudes by centrifugal and "Coriolis" effects, as well complex structure in the full velocity distributions of ions. A paper is being readied for submission to JGR [Ref. 5].

Field-Aligned Flows and Trapped Ion Distributions

Referees' reports were received on the JGR submission on the statistical study of the latitudinal distributions of core plasmas along the L=4.6 field line using DE-1/RIMS data [Ref. 25]. Both referees have requested substantial revision. Such revision and responses to the referees have been prepared and resubmitted to JGR. We are also working on further careful case study analysis of L=4.6 ion distributions from the DE-1 orbits where apogee is near the magnetic equator. In this analysis, we are characterizing the near-equatorial trapped distributions as bi-Maxwellians and have obtained the proton perpendicular and parallel temperatures and densities. We have done this for a couple of

cases and are presently concerned with calibration viz. a similar analysis for a pass published by Olsen et al.[1994].

The IUGG 1991-4 Quadrennial report on ionospheric outflows and ionospheric plasma in the magnetosphere[Ref. 6] has been accepted and will appear in June 1995.

Plasmasphere-Ionosphere Coupling

A short study has been carried out on heating processes in low density flux tubes in the outer plasmasphere. The purpose was to determine whether the high ion temperatures observed in these flux tubes were due to heat sources operating through the thermal electrons or directly to the ions. In the case study we performed, results clearly indicated that only direct ion heating was capable of producing the observed ion temperatures. However, consequences of this heating included ion temperatures at low altitudes which far exceeded observations, as well as ion composition at high altitudes with concentrations of heavy ions (particularly O^+) which also greatly exceeded observed levels. We suggested that these effects might be due to too much heat being conducted to low altitudes, due to the very high thermal conductivity under the low-density, high-temperature conditions being simulated. These results were reported to the Guntersville workshop [Ref. 7].

In a follow-on study, we followed our own suggestion and examined a possible mechanism for reducing the ion thermal conductivity under the low density conditions being simulated. Our mechanism was that when ion mean free paths extended from the location of interest to or beyond the ionosphere, only those particles in the loss cone would be effective transporters of heat out of the plasmasphere, since other particles would be trapped and retain the heat in the plasmasphere. We derived a simple mathematical model to represent this situation and applied it in place of the standard Spitzer-Harm thermal conductivity coefficient. This mechanism basically had the desired results. Heat conduction was significantly reduced. As result, less heat was required in the simulations to raise ion temperatures at high altitudes to observed levels, simulated temperatures at low altitudes were lower, and simulated concentrations of O^+ at high altitudes were reduced to levels much closer to those observed. These results were presented to the Fall AGU Meeting [Ref. 8] and a paper [Ref. 9] is being prepared for GRL..

Referees' reports were also received on the short paper submitted to Annales de Geophysique[Ref. 10] regarding dual spacecraft estimates of ion temperature profiles and heat flows in the plasmasphere-ionosphere system. We are presently working on revising the paper according to the referees' comments. Among other results of this revision effort, we have found from comparisons of our analytic temperature profiles based on thermal conductivity alone with full FLIP simulations that the distributed heating from photoelectrons (through the thermal electrons) has a significant effect on the temperature profile.

ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

Empirical Model

The focus in the empirical model work has shifted to establishing final calibration files and procedures. The high-low mass channel files have been extended, based on daily averages from comparisons of high and low mass channel He^+ . Studies which require only number density ratios can be carried out without problem; only those which require absolute densities need the further refinements which are in process.

HARDWARE

We (M. L. Adrian) have participated extensively in testing, modifying, assembling and calibrating the flight hardware for the Thermal Electron Capped Hemisphere Spectrometer (TECHS) experiment. Additional details, presented in a separate report covering portions of this activity, has been provided to the SSL technical monitor [Ref. 11]. This instrument was successfully flown on the Sounding of the Cleft Ion Fountain Energization Region (SCIFER) rocket flight on January 25, 1995, from the Andoya Rocket Range, Norway and the instrument performance was outstanding, according to the PI (C. J. Pollock).

MEETINGS

Dr. Horwitz was co-convenor of the Workshop on Coupling of Micro- and Macroscale Processes in Space Plasma Transport, held in Guntersville, AL, on October 16-19, 1994. The workshop was attended by Drs. Comfort, Wilson, Ho, and Liu, as well as a number of graduate students. Dr. Wilson presented an invited talk [Ref. 12], Drs. Comfort, Brown and Ho presented invited posters [Ref. 7, 2, 3] and 3 other papers [Ref. 4, 13, 14] were presented by this group as authors or co-authors.

Drs. Comfort and Wilson presented papers [Ref. 8, 15, 16] at the Fall AGU Meeting in San Francisco, where Dr. Comfort also chaired a poster session.

PUBLICATIONS

In addition to those noted above, the following papers are at the indicated stage in the publication cycle:

Papers published are those on: the survey of properties of outflowing polar cap O^+ , from RPA analysis of DE-1/RIMS data, together with further comparisons with the centrifugally-accelerated polar wind [Ref. 18], pitch angle distributions of low energy ions at high latitudes [Ref. 19], comparisons of plasma composition from observations and simulations in the midlatitude ionosphere [Ref. 20].

Papers accepted for publication are those on: thermal structure of the plasmasphere [Ref. 21], transition from collisional to collisionless outflow [Ref. 22], and Pc 3 Alfvén wave propagation [Ref. 23].

Papers submitted for publication and in review are those on: ion conic production via the Current-Driven ion Cyclotron Instability (CDICI) [Ref. 24], the streaming trapped ion interface in the equatorial inner magnetosphere [Ref. 25], observations and simulations of centrifugally accelerated O^+ outflows [Ref. 26], azimuthal variation of the equatorial plasmapause [Ref. 27], and simulation problems for ion temperatures in low density flux tubes [Ref. 28].

REFERENCES

1. Brown, D. G., J. L. Horwitz, and G. R. Wilson, Synergistic effects of hot plasma-driven potentials and wave-driven ion heating on auroral ionospheric plasma transport, submitted to *J Geophys. Res.*, 1994.
2. Brown, D. G., P. G. Richards, G. R. Wilson, J. L. Horwitz, and C. W. Ho, Effects of precipitating auroral electrons on ionospheric plasma transport: A dynamic semikinetic model, presented to the Workshop on Coupling of Micro and Mesoscale Processes in Space Plasma Transport, Guntersville, AL, October, 1994.
3. Ho, C. W., J. L. Horwitz, G. R. Wilson, and D. G. Brown, Field-aligned transport of ionospheric O^+ ions from 200 km to $1 R_E$ due to $E \times B$ convection heating and centrifugal acceleration: A generalized SemiKinetic (GSK) treatment, presented to the Workshop on Coupling of Micro and Mesoscale Processes in Space Plasma Transport, Guntersville, AL, October, 1994.
4. Lee, J., J. L. Horwitz, G. R. Wilson, J. Lin, and D. G. Brown, On the interaction of cold ionospheric plasma inflows with the preexisting equatorial warm plasmas on inner magnetospheric flux tubes: warm plasma thermalization and effects of varying ionospheric inflow speeds, presented to the Workshop on Coupling of Micro and Mesoscale Processes in Space Plasma Transport, Guntersville, AL, October, 1994.
5. Liu, C. and J. L. Horwitz, Dipolarization effects on ion distributions on closed field lines, to be submitted to *J Geophys. Res.*, 1995.
6. Horwitz, J. L., The ionosphere's wild ride in outer space, *Rev. Geophys.*, in press, 1995.
7. Comfort, R. H., P. G. Richards, P. D. Craven, M. O. Chandler, Problems with thermal conductivity in Simulating ion temperatures in low density flux tubes, Invited Poster, presented to the Workshop on Coupling of Micro- and Macroscale Processes in Space Plasma Transport, Guntersville, AL, October 16-19, 1994.
8. Comfort, R. H., and P. D. Craven, A modified thermal conductivity for low density flux tubes, *EOS*, 75, 547, 1994; presented to the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 5-9, 1994.

9. Comfort, R. H., and P. D. Craven, Modification of thermal conductivity for outer plasmasphere, low density flux tubes, to be submitted to *Geophys. Res. Lett.*, 1995.
10. Neergaard, L. F., J. L. Horwitz, R. H. Comfort, and P. C. Anderson, Dual spacecraft estimates of semi-analytic temperature profiles and heat flows, submitted to *Ann. Geophys.*, 1994.
11. Adrian, Mark L., Status Report Covering Personal Research for Summer 1994 under University Course PH 795-01, University of Alabama in Huntsville, August, 1994.
12. Wilson, G. R., The consequences of collisions (Coulomb and otherwise) for space plasma transport, presented to the Workshop on Coupling of Micro- and Macroscale Processes in Space Plasma Transport, Guntersville, AL, October 16-19, 1994.
13. Gallagher, D. L., P. D. Craven, R. H. Comfort, An empirically derived time-dependent plasmasphere, presented to the Workshop on Coupling of Micro- and Macroscale Processes in Space Plasma Transport, Guntersville, AL, October 16-19, 1994.
14. Frey, M. A., C. E. Rasmussen, D. L. Carpenter, J. L. Horwitz, N. C. Maynard, M. Smiddy, R. W. Spiro, J. R. Wygant, R. D. Zwikl, and J. C. Joselyn, A study of the evolution of plasmaspheric structures during a magnetic storm, presented to the Workshop on Coupling of Micro- and Macroscale Processes in Space Plasma Transport, Guntersville, AL, October 16-19, 1994.
15. Gristina, D., and G. R. Wilson, O⁺ velocity distributions resulting from wave-particle interactions in the topside ionosphere, *EOS*, 75, 573, 1994; presented to the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 5-9, 1994.
16. Ho, C. W., J. L. Horwitz, and G. R. Wilson, Effects on high-latitude ionospheric ion upflows due to $\mathbf{E} \times \mathbf{B}$ frictional heating and centrifugal acceleration, *EOS*, 75, 573, 1994; presented to the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 5-9, 1994.
17. Ho, C. W., J. L. Horwitz, and T. E. Moore, DE1 observations of O⁺ stream bulk parameters and comparison with a model of the centrifugally-accelerated polar wind, *Geophys. Res. Lett.*, 21, 2459, 1994.
18. Wilson, G. R., Kinetic modeling of O⁺ upflows resulting from $\mathbf{E} \times \mathbf{B}$ convection heating in the high-latitude F-region ionosphere, *J. Geophys. Res.*, 99, 17453, 1994.
19. Giles, B. L., C. R. Chappell, T. E. Moore, R. H. Comfort, and J. H. Waite, Jr., Statistical survey of pitch angle distributions in core (0-50 eV) ions from Dynamics Explorer 1: Outflow in the auroral zone, polar cap, and cusp, *J. Geophys. Res.*, 99, 17483, 1994.
20. Craven, P. D., R. H. Comfort, P. G. Richards, and J. Grebowsky, Comparisons of modeled N⁺, O⁺, H⁺, and He⁺ in the mid-latitude ionosphere with mean densities and temperatures from Atmospheric Explorer, *J. Geophys. Res.*, 100, 257, 1995.
21. Comfort, R. H., Thermal structure of the plasmasphere, *Adv. Space Res.*, in press, 1995.
22. Wilson, G. R., B. L. Giles, and M. O. Chandler, Collisional to collisionless ion outflow at the ionosphere-magnetosphere interface, *Adv. Space Res.*, in press, 1995.
23. Zhang, X., R. H. Comfort, D. L. Gallagher, J. L. Green, Z. E. Musielak, and T. E. Moore, Magnetospheric filter effect for Pc 3 Alfvén mode waves, *J. Geophys. Res.*, in press, 1995.

24. Brown, D. G., J. L. Horwitz, and G. R. Wilson, Generalized SemiKinetic (GSK) modeling of auroral conic production due to the Current-Driven-Ion-Cyclotron-Instability (CDICI), submitted to *J. Geophys. Res.*, 1995.
25. Lin, J., J. L. Horwitz, D. L. Gallagher, and C. J. Pollock, Streaming/trapped ion interface in the equatorial inner magnetosphere, submitted to *J. Geophys. Res.*, 1995.
26. Ho, C. W., J. L. Horwitz, and T. E. Moore, Observations and simulations of centrifugally-accelerated polar O⁺ outflows, submitted to *Proceedings of the International Conference on Substorms II*, ed. S.-I. Akasofu, and J. R. Kan, 1994.
27. Gallagher, D. L., P. D. Craven, R. H. Comfort, and T. E. Moore, On the azimuthal variation of the equatorial plasmopause, submitted to *J. Geophys. Res.*, 1994.
28. Comfort, R. H., Problems in simulating ion temperatures in low density flux tubes, submitted to AGU monograph on *Cross-scale Coupling in Space Plasmas*, 1995.
29. Brown, D. G., P. G. Richards, G. R. Wilson, J. L. Horwitz, and C. W. Ho, Effects of precipitating auroral electrons on ionospheric plasma transport: A dynamic semikinetic model, submitted to AGU monograph on *Cross-scale Coupling in Space Plasmas*, 1995.
30. Ho, C. W., J. L. Horwitz, G. R. Wilson, and D. G. Brown, Field-aligned transport of ionospheric O⁺ ions from 200 km to 1 R_E due to $\mathbf{E} \times \mathbf{B}$ convection heating and centrifugal acceleration: A generalized SemiKinetic (GSK) treatment, submitted to AGU monograph on *Cross-scale Coupling in Space Plasmas*, 1995.
31. Lee, J., J. L. Horwitz, G. R. Wilson, J. Lin, and D. G. Brown, On the interaction of cold ionospheric plasma inflows with the preexisting equatorial warm plasmas on inner magnetospheric flux tubes: warm plasma thermalization and effects of varying ionospheric inflow speeds, submitted to AGU monograph on *Cross-scale Coupling in Space Plasmas*, 1995.
32. Wilson, G. R., The consequences of collisions (Coulomb and otherwise) for space plasma transport, submitted to AGU monograph on *Cross-scale Coupling in Space Plasmas*, 1995.